SURVEY LHC low-beta alignment

REMOTE Alignment control system of the LHC low beta quadrupoles

Project description
The low beta quadrupole magnets in the CERN Large Hadron Collider (LHC) are installed in high radiation areas on either side of the experiments. The system is equipped with sophisticated hydrostatic levelling and stretched-wire position measuring systems. A UNICOS-based control system using motorized jacks was installed to correct the alignment of the magnets remotely. Dedicated monitoring and control applications have been developed to allow the LHC operation team to supervise this complex system from the CERN Control Center. This paper gives an overview of the present controls architecture and introduces the foreseen operational tools to assist the beam operation.

Instrumentation
The low beta quadrupoles position is monitored using Wire Position Systems (WPS) and Hydrostatic Leveling Systems (HLS). They are based on a capacitive system where a distance is measured with respect to a reference (a stretched wire or a surface of water respectively). They are located in fiducials which have been pre-referenced using laser measurements.

Additionally there are also Dimensional Offset Measurement Sensors (DOMS) measuring the distance between the Inner Triplet Line and an offset reference (used in the high luminosity experiments: IP1, IP5). Correction of the capacitive sensor readings and dilatation effects is made using PT100 (Steiner) sensors located all around the triplet. The instrumentation is listed in Table 1 below.

Stepping motor gearboxes are plugged into the jacks which support the cryomagnets; they allow the movement to the desired position.

<table>
<thead>
<tr>
<th>Instruments</th>
<th>Range</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>HLS (position)</td>
<td>5 mm</td>
<td>100</td>
</tr>
<tr>
<td>WPS (position)</td>
<td>10mm x 10mm (2 axis)</td>
<td>68</td>
</tr>
<tr>
<td>DOMS (position)</td>
<td>10 mm</td>
<td>24</td>
</tr>
<tr>
<td>Steiner (temperature)</td>
<td>Various</td>
<td>128</td>
</tr>
<tr>
<td>Stepping motors</td>
<td>4mm</td>
<td>128</td>
</tr>
</tbody>
</table>

Control Architecture
The control system for the alignment of the low beta quadrupoles is based on the FESA and the UNICOS frameworks. The architecture of the control system is shown in Figure 3. FESA is used, at the front-end level to interface to the signal conditioners of the sensors and to the actuators both connected to a WorldFip network. UNICOS is used to develop the Supervisory Control and Data Acquisition system (SCADA).
One FEC is used in each experimental insertion. Two PCI WorldFip controllers (31.25 KHz) interface the equipment located on the left and on the right of the insertion. The total length of each bus does not exceed 150 meters, hence no repeaters are deployed. WorldFip is used mainly because of its radiation tolerance.

The FEC acquisition and calculation cycle is 1 Hz; this includes the capturing of the signal conditioner raw data and its conversion to engineering sensor information.

The four low beta quadrupole alignment systems (ATLAS, CMS, LHCb and Alice) are managed by a single data server running the SCADA system. The data server is an off-the-shelf HP ProLiant which runs Linux SLC4 and is equipped with a RAID system. Several Windows and Linux PCs have been deployed as Human-Machine Interface (HMI) clients both, for expert users in local control rooms and for the LHC operator crews to monitor the position of the low beta insertion magnets from the CERN Control Center (CCC).

Publications
- Icalepcs 2009: REMOTE ALIGNMENT CONTROL SYSTEM OF THE LHC LOW BETA QUADRUPOLES

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